Application	:	A.02-11-017
Exhibit Number	:	ORA-
Commissioner	:	M. R. Peevey
Admin. Law Judge	:	M. Cooke
Witnesses	:	T. M. Renaghan

CALIFORNIA PUBLIC UTILITIES COMMISSION

ORA

Office of Ratepayer Advocates

Report on Total Factor Productivity Analysis For Pacific Gas and Electric Company

General Rate Case

Test Year 2003

San Francisco, California
April 11, 2003

TOTAL FACTOR PRODUCTIVITY ANALYSIS

I. INTRODUCTION

This report analyzes Pacific Gas and Electric's (PG&E) productivity performance for its electric and gas departments over the period 1986 through test year 2003. Since 1986 (D.86-12-095) the California energy utilities, (Pacific Gas and Electric, San Diego Gas and Electric, Southern California Edison, and the Southern California Gas Company), have been required to file reports on historic and forecast firm specific productivity growth. PG&E's Report on Total Factor Productivity (PG&E-7) fulfills this requirement.

Section II discusses ORA's recommendations. Section III discusses the concept of total factor productivity. Section's IIIA and IIIB summarize PG&E's electric and gas total factor productivity findings. Finally, section's IVA and IVB discuss ORA's electric and gas total factor productivity results.

II. SUMMARY /RECOMMENDATIONS

PG&E concludes that over: "the historical period 1987-2001, the combined electric and gas productivity [growth] rate is 0.5 percent…If the forecast period is included, then the combined electric and gas distribution department average productivity growth is estimated at negative 0.7 percent and the estimate is 0.4 percent if customers are used as the measure of output." (Pacific Gas and Electric Company, 2003 Test Year, PG&E-7, Report on Total Factor Productivity, p. 8-1). This estimate represents a weighted average of total factor productivity growth rates to the electric and gas departments. Using a slightly different measure of output, ORA arrived at nearly identical estimates of electric and gas distribution productivity growth. ORA recommends no additional adjustments to PG&E's operations and maintenance request beyond that contained in ORA's Results of Operations report.

III. DISCUSSION/ANALYSIS

Productivity is simply a measure of how well a firm, industry, or an economy transforms inputs into outputs. A commonly reported measure of productivity is labor productivity. Labor productivity measures how well a firm utilizes its labor inputs to produce a unit of output. This measure of productivity, while useful, ignores the fact that a firm uses more than labor to produce a unit of output. An electric or gas utility requires plant, (capital), materials, (operations and maintenance), as well as labor to distribute a kilowatt hour of electricity or therm of natural gas to its customers. Focusing on a single input such as labor could produce a distorted picture of a firm's overall performance.

To capture overall productivity performance economists have developed the concept of total factor productivity (TFP). TFP measures how well a firm combines all its inputs to produce a unit of output. Often the term multi-factor productivity (MFP) is substituted for TFP. The concept, however, is the same. "Multi-factor productivity measures describe the relationship between output in real terms and the inputs involved in its production. This does not measure the specific contributions of labor, capital, and any other factor of production. Rather, multi-factor productivity is designed to capture the joint influences on economic growth of technological change, efficiency improvements, returns to scale, reallocation of resources due to shifts in factor inputs across industries and other factors." (United States Department of Labor, Bureau of Labor Statistics, "Survey of Methods," July 23, 2002, p. 1).

TFP studies typically focus on the growth in TFP over a multi-year period. This is because "total factor productivity fluctuates considerably from year to year in all industries, exhibiting pro-cyclical movements over the business cycle (rising when the economy picks up and vice versa). These annual variations are not informative about movements in the underlying trends in unit cost…It is standard scientific practice to "smooth" the annual series to reveal secular changes. One

common and simple procedure…is to use an average growth in TFP over a suitably long period of time." (Direct Prepared Testimony of Dr. Mark Schankerman, Pacific Gas and Electric Company, Chapter 3, Benchmarks For The Hybrid Cap, p. 3-2). A period of ten years is considered by many to be the minimum time period from which one can draw reasonable inferences about a firm's TFP performance. This is why PG&E and ORA concentrate on the 1986-2003 period rather than focusing upon a single year such as test year 2003.

Productivity growth rates can also be influenced by institutional changes in an industry. This is particularly the case for PG&E. In the period covered by this report PG&E faced bankruptcy as well as continuing efforts at electric restructuring. As PG&E explains: "For purposes of this report and the productivity estimates obtained, no account is taken of the recent energy crises and instability of the electric industry. This is the best that can be accomplished given current data availability, and given that the transition in electric industry restructuring is still in progress and its direction is uncertain." (Pacific Gas and Electric, Test Year 2003, Report on Total Factor Productivity, (PG&E-7), p. 8-1).

MEASURING TOTAL FACTOR PRODUCTIVITY

There are two approaches to measuring TFP-parametric and non-parametric. The non-parametric approach is based on constructing indices of outputs to inputs. The growth in TFP is then measured as the difference in the growth of the output index less the growth in the input index. The preferred method of aggregating inputs and outputs is the Divisia index. The Divisia index is discussed in the appendix to this report.

Parametric measures of TFP rely on econometrically estimated cost functions. To construct a parametric measure of TFP, the firm's costs are regressed on input prices, output, and time. In past general rate cases ORA and the California energy utilities have presented TFP estimates derived from econometrically estimated cost functions. These cost functions were

also used to forecast the utilities' non-fuel operations and maintenance expenses.

As a result of recent electric and gas restructuring efforts in California the econometric approach to TFP measurement is no longer feasible. SCE, for example, notes that: "SCE and PG&E have used econometric cost functions to derive total factor productivity estimates in general rate cases. These estimates were for the operations of the vertically integrated utility, encompassing generation, transmission, and distribution…Since 1995 our utility have undergone a significant transformation…These changes make it difficult, if not impossible, to sustain the assumption of an unchanging production process that is required by the econometric cost function approach." (Southern California Edison, 2003 General Rate Case, Productivity Measurement, p. 9). Furthermore, "there is the question of the econometric procedures used to obtain the estimates. The highly complicated structure of the models usually requires non-linear estimation techniques which are valid only under special circumstances, and there are questions about the statistical properties of the resulting estimates." (Hulten, C.R., "Total Factor Productivity: A Short Biography, Working Paper 7471," National Bureau of Economic Research, January 2000, p. 23). The cost function approach, however, "has the advantage of allowing the researcher to identify factors contributing to productivity growth. An econometric model may be used to separate the effects on multi-factor productivity of factors not controlled by the firm, for example, weather, input prices, from actual changes in the firm's operating efficiency." (Pacific Gas and Electric, 1999 Test Year, Report on Total Factor Productivity, PG&E-5, pp. 5-6). Hulten concludes that: "there is no reason why the two approaches should be viewed as competitors." (Hulten, C.R., "Total Factor Productivity: A Short Biography", Working Paper 7471, National Bureau of Economic Research, January 2000, p. 23). In other

words, the parametric and non-parametric approaches yield valid estimates of TFP growth.

PG&e Electric TFP Growth

PG&E presents two measures of electric distribution TFP growth. PG&E's results are summarized in Table 1. The first measure is based on output defined as total electric sales. The second defines output as total electric customers. In both measures of TFP growth inputs include labor, capital, (distribution plant), and materials (operations and maintenance). The derivation of the inputs is discussed in greater detail in the technical appendix to this report.

The results reported in Table 1 show that when output is defined as total sales PG&E's historical, 1987-2001, electric TFP grew on average by 0.28 percent per year. If the forecast period is included, 1987-2003, electric TFP declined by 0.28 percent per anum. For test year 2003, PG&E projects a 1.78 percent decline in electric TFP. PG&E attributes this decline in electric TFP growth to the impacts of conservation. "If output growth is suppressed due to successful conservation impacts and input growth does not decline in the same proportion…then measured productivity growth will decline." (Pacific Gas and Electric, Test Year 2003, Report on Total Factor Productivity, PG&E-7, p. 8-5). In other words, without conservation, output growth would be higher, resulting in higher measured TFP growth.

Table 1

PG&E Electric Distribution TFP Growth

1987-2003

(Percent Change)

Year	Output Total Sales	Output Total Electric Customers
1987	10.39	2.56
1988	2.63	3.31
1989	-0.96	0.22
1990	0.44	-2.69
1991	-1.85	-1.09
1992	-0.30	-1.15
1993	-1.97	-1.68
1994	4.94	5.82
1995	-0.22	0.36
1996	-2.33	-0.87
1997	0.00	-12.65
1998	1.16	4.03
1999	2.15	3.22
2000	-2.74	-3.09
2001	1.80	4.77
2002	-7.13	-1.25
2003	-1.78	-0.84
Average 1987-2001	**0.28**	**0.07**
Average 1987-2003	**-0.28**	**-0.01**

PG&E notes that if recorded output growth were adjusted for conservation by setting use per customer at the annual average 1987-2001 growth rate then measured TFP growth would rise to 0.30 percent.

If electric customers are defined as the appropriate output measure then historic TFP growth, 1987-2001, averages 0.07 percent per year. Over the entire 1987-2003 period, the results reported in Table 2 show an average annual electric TFP growth rate of –0.01 percent per year.

B. PG&E Gas TFP Growth

Similar to the electric department, PG&E presents two measures of gas distribution TFP growth. The first measure is based on total gas sales while the second defines gas output as the number of gas customers. Analagous to the electric department, inputs consist of labor, capital, (distribution plant), and materials (operation and maintenance).

PG&E gas distribution results are summarized in Table 2. When output is defined as total gas sales PG&E's results show that over the historical period, 1987-2001, gas department TFP grew, on average, by 1.13 percent per year. Over the entire 1987-2003 period gas TFP grew by 0.39 percent per annum. PG&E attributes the decline in gas TFP growth in the forecast period to a decline in gas demand. "For the period 1987-2001, the average annual increase in MDth was 0.01 percent, for the forecast period 2002-2003, the average annual increase is a negative 4.9 percent." (Pacific Gas and Electric, Test Year 2003, Report on Total Factor Productivity, PG&E-7, p. 8-7).

When gas customers are defined as the relevant output measure, historic 1987-2001, gas department TFP grew, on average, by 1.55 percent per year. When the forecast, 1987-2003, period is included average annual gas TFP growth declines slightly to 1.35 percent per year.

Table 2

PG&E Gas Department TFP Growth

1987-2003

(Percent Change)

Year	Output Total Sales	Output Total Gas Customers
1987	13.44	2.86
1988	4.72	1.83
1989	2.90	3.35
1990	-0.67	2.24
1991	0.00	1.40
1992	2.47	-0.24
1993	-13.31	-0.35
1994	7.64	-2.18
1995	-22.30	-4.02
1996	5.00	6.16
1997	-6.47	-1.33
1998	13.78	5.83
1999	0.77	2.64
2000	4.91	-1.23
2001	3.82	6.11
2002	-10.44	-1.99
2003	0.10	1.70
Average 1987-2001	**1.13**	**1.55**
Average 1987-2003	**0.39**	**1.35**

IV. DISCUSSION/ANALYSIS

This section discusses ORA's estimates of electric and gas department TFP growth. For the electric and gas departments ORA constructed alternative measures of output growth. Finally, this section discusses ORA's estimates of labor productivity and O&M productivity growth for PG&E's electric and gas departments.

A. ORA Electric TFP Growth

ORA evaluated PG&E's electric distribution TFP results by constructing an alternative measure of electric distribution output growth. Specifically, ORA constructed a Divisia index of electric output defined as the revenue weighted sum of sales to the residential, commercial, large light and power, and other public authority classes of service. Following PG&E's approach inputs include labor, capital, and materials.

ORA's results are reported in Table 3. PG&E's results are provided for comparison. ORA's definition of output growth results in slightly higher TFP growth rates than PG&E. Over the historic 1987-2001 period, ORA's definition of output results in an electric TFP growth rate of 0.58 percent per year. Similar to PG&E, ORA also projects a decline in TFP growth in the forecast period. For example, over the 1987-2003 period, ORA estimates an annual average TFP growth rate of 0.25 percent per anum.

Table 3

ORA and PG&E Electric TFP Growth Rates

1987-2003

(Percent Change)

Year	ORA Output Total Sales	PG&E Output Total Sales
1987	6.81	10.39
1988	4.48	2.63
1989	-2.16	-0.96
1990	1.89	0.44
1991	-2.43	-1.85
1992	-0.57	-0.30
1993	-4.13	-1.97
1994	7.15	4.94
1995	-1.90	-0.22
1996	1.88	-2.23
1997	-10.67	0.00
1998	3.05	1.16
1999	6.32	2.15
2000	-1.33	-2.74
2001	3.18	1.80
2002	-4.78	-7.13
2003	0.28	-1.78
Average 1987-2001	**0.58**	**0.28**
Average 1987-2003	**0.25**	**-0.28**

ORA and PG&E's electric TFP results are consistent with a recent study of nationwide electric distribution TFP growth. This study found that over the period 1987-2001, "The trend growth in the TFP index was 0.52 percent per annum. By way of comparison, the federal government's index of multi-factor productivity index for the non-farm business sector of the U.S. economy grew an 0.89 % annual average rate over an analogous period. The trend growth in the federal government's index of the multi-factor productivity of the U.S. gas and electric utilities was 0.80 % over an analogous period." (Lowry, M.N., Hovde, D.H., Getachew, L., and Kaufman, J., "X Factor Calibration For San Diego Gas and Electric," Madison, WI: December 12, 2002, p. 2).

B. ORA Gas TFP Growth

Similar to the electric department, ORA analyzed gas department TFP growth by constructing an alternative measure of gas output growth. ORA constructed a Divisia index of output defined as the revenue weighted sum of gas sales to the residential, commercial, industrial, cogeneration, utility electric generation, and resale classes of service. Due to data limitations ORA restricted its analysis to the 1990-2003 period. Gas department inputs include labor, capital, and materials.

Table 4 compares ORA's gas distribution TFP growth rates to PG&E's results. ORA's output definition yields lower gas TFP growth rates than PG&E's. Over the historic, 1990-2001 period, ORA estimates a decline in gas TFP of 0.35 percent per year. Over the same period [Table 4, column (2)], PG&E estimates a gas TFP growth rate of 1.13 percent per year. Over the historic and forecast period, 1990-2003, ORA arrives at an annual average gas TFP growth rate of 0.22 percent. Over this same period, PG&E arrives at a slightly higher gas TFP growth rate of 0.39 percent.

Table 4

ORA and PG&E Gas Distribution TFP Growth

1987-2003

(Percent Change)

Year	ORA Output Total Sales	PG&E Output Total Sales
1987	Na	13.44
1988	Na	4.72
1989	Na	2.90
1990	-0.70	-0.67
1991	-3.03	0.00
1992	-4.74	2.47
1993	-2.27	-13.31
1994	4.20	7.64
1995	-17.34	-22.30
1996	4.94	5.00
1997	-0.29	-6.47
1998	17.97	13.78
1999	6.55	0.77
2000	-9.69	4.91
2001	0.18	3.82
2002	5.57	-10.44
2003	1.74	0.10
Average 1990-2001	**-0.35**	**1.13**
Average 1990-2003	**0.22**	**0.39**

A recent study of nationwide gas distribution TFP growth concluded that over the period 1990-2001, "the trend in the TFP of the industry was 0.93 %…The trend for gas distribution is plainly very much in line with the trend for the U.S. economy and a little above that for the gas and electric industry as a whole." (Lowry, M.N., Hovde, D.H., Getachew, L., and Kaufman, J., "X Factor Calibration For San Diego Gas and Electric", Madison, WI: December 12, 2002, p. 17). PG&E's results compare favorably to the results of this study. Recall that Table 2 showed that over the 1987-2003 period, PG&E's gas department averaged TFP growth averaged 1.35 percent per annum.

C. Labor Productivity Growth

Table 5 reports ORA's estimates of electric labor productivity growth under ORA's and PG&E's sales based output definitions as well as outputdefined as total customers. Labor productivity growth is measured as the growth in output less the growth in labor inputs. Table 5 shows that regardless of how electric department output is measured, the productivity growth rates are strikingly similar. Over the historic, 1987-2001 period, for example, the electric labor productivity labor productivity growth rates reported in Table 5 average around 4 percent. As in the case of ORA and PG&E's electric TFP estimates are slightly lower when the forecast period is included. The labor productivity growth rates reported in Table 5 also compare favorably to the labor productivity growth rates for the U.S. electric and gas industry. Over the 1987-1998 period labor productivity in the U.S. electric and gas industry grew on average by 2.70 percent per year.

Table 5

ORA and PG&E Labor Productivity Growth Rates

1987-2003

(Percent Change)

Year	ORA Output Total Sales	PG&E Output Total Sales	ORA/PG&E Output Total Customers
1987	19.48	23.48	14.71
1988	2.22	0.40	1.07
1989	9.86	11.21	12.54
1990	-0.52	-1.95	-5.00
1991	9.03	9.68	10.53
1992	-2.42	-2.16	-3.00
1993	-3.81	-1.64	-1.34
1994	21.07	18.56	19.56
1995	-10.44	-8.91	-8.38
1996	8.54	4.08	5.64
1997	-23.54	-22.61	-25.24
1998	29.12	26.76	30.45
1999	12.02	7.61	8.74
2000	3.75	2.28	1.91
2001	-5.63	-4.23	-1.45
2002	-3.18	-5.57	0.40
2003	1.72	-0.36	1.36
Average 1987-2001	**4.58**	**4.20**	**4.04**
Average 1987-2003	**3.95**	**3.36**	**3.67**

Table 6 reports labor productivity growth rates for PG&E's gas distribution department. As in the case of gas TFP, ORA's results are reported for the 1990-2003 period. Under ORA's output definition gas labor productivity averaged 1.10 percent over the 1990-2001 period. If the forecast period is included, 1990-2003, PG&E's gas labor productivity averages a slightly higher 1.22 percent per year. With PG&E's definition of output the labor productivity growth rates shown in Table 6 are higher. For example, over the historic, 1987-2001 period, gas labor productivity growth averages 2.30 percent, and including the historic and forecast periods, 1987-2003, it averages 3.43 percent per annum. Defining output as total customers yields an historic labor productivity growth rate of 3.46 percent per year. For the entire 1987-2003 period customer based gas labor productivity averages 2.91 percent per year.

Table 6

ORA and PG&E Gas Labor Productivity Growth

1987-2003

(Percent Change)

Year	ORA Output Total Sales	PG&E Output Total Sales	ORA/PG&E Output Total Customers
1987	Na	26.46	14.67
1988	Na	3.56	0.70
1989	Na	8.50	8.97
1990	-2.58	-2.56	0.39
1991	-1.09	2.05	3.43
1992	-6.39	0.68	-1.98
1993	-4.38	-15.90	-2.52
1994	10.38	14.03	3.63
1995	-31.65	-35.75	-20.64
1996	24.65	24.73	26.10
1997	-2.41	-8.46	-3.42
1998	34.39	29.61	20.55
1999	10.60	4.60	6.54
2000	-14.02	-0.11	-5.96
2001	-4.23	-0.76	1.44
2002	4.10	-11.68	-3.38
2003	1.08	-0.57	1.01
Average 1990-2001	**1.10**	**1.01**	**2.29**
Average 1990-2003	**1.32**	**0.11**	**1.79**
Average 1987-2001	**Na**	**2.30**	**3.46**
Average 1987-2003	**Na**	**3.43**	**2.91**

D. O&M Productivity Growth

Table 7 reports estimates of operations and maintenance (O&M) productivity growth under the various output definitions discussed previously. Operations and maintenance productivity growth is measured as output growth less the growth in O&M inputs. The results in Table 7 show that, as in the case of labor productivity, regardless of how output is measured the O&M productivity results are very similar. For example, over the historic 1987-2001 period, electric O&M productivity growth averaged around two percent per year. If customers are used as the output measure, historic O&M productivity growth averages 2.12 percent per year. Furthermore, the estimates in Table 7 show slightly lower growth rates when the forecast period is included. This is consistent with PG&E's and ORA's findings for the pattern of electric TFP and labor productivity growth.

Table 7

ORA and PG&E Electric O&M Productivity Growth

1987-2003

(Percent Change)

Year	ORA Output Total Sales	PG&E Output Total Sales	ORA/PG&E Output Total Customers
1987	16.04	19.92	11.41
1988	10.67	8.71	9.44
1989	0.35	1.58	2.79
1990	-1.23	-2.64	-5.67
1991	-5.94	-5.38	-4.65
1992	-1.44	-1.17	-2.02
1993	-3.05	-0.86	-0.56
1994	9.64	7.37	8.27
1995	-0.01	1.68	2.28
1996	4.04	-0.23	1.26
1997	-20.94	-19.45	-22.68
1998	13.92	11.83	15.00
1999	14.33	9.83	10.98
2000	-6.30	-7.63	-7.96
2001	9.12	10.74	13.96
2002	-5.08	-7.42	-1.56
2003	1.73	-0.36	1.36
Average 1987-2001	**2.61**	**2.29**	**2.12**
Average 1987-2003	**2.11**	**1.56**	**1.86**

Table 8 reports O&M productivity growth under the output definitions discussed in this report. Using ORA's output definition, historic gas O&M productivity growth declined by less than one percent over the 1987-2001 period. With PG&E's output definition, historic1987-2001, gas O&M productivity growth average 1.34 percent per year. If output is defined as total gas customers, historic gas O&M productivity growth averaged 1.61 percent per year. When the forecast, 1990-2003 period is included, ORA's results show a slight decline in O&M productivity growth. With PG&E's output measure including the 1987-2003 period, yields an average gas O&M productivity growth rate of 0.18 percent per annum. Finally, if output is defined as total customers, historic and forecast gas O&M productivity growth averaged approximately one percent per year.

Table 8

ORA and PG&E Gas O&M Productivity Growth Rates

1987-2003

(Percent Change)

Year	ORA Output Total Sales	PG&E Output Total Sales	ORA/PG&E Output Total Customers
1987	Na	17.89	6.90
1988	Na	0.20	-2.56
1989	Na	10.22	10.70
1990	1.78	1.81	4.90
1991	-1.82	1.30	2.67
1992	-5.94	1.18	-1.50
1993	-4.98	-15.71	-3.12
1994	-12.65	-9.76	-17.99
1995	-31.48	-35.59	-20.43
1996	24.68	24.76	26.13
1997	-7.92	-13.63	-8.87
1998	35.57	30.75	21.62
1999	4.37	-1.30	0.53
2000	-20.72	-7.90	-13.30
2001	11.94	15.99	18.56
2002	-1.75	-16.64	-8.81
2003	1.08	-0.56	1.01
Average 1990-2001	**-0.60**	**-0.67**	**1.03**
Average 1990-2003	**-0.56**	**-1.81**	**0.30**
Average 1987-2001	**Na**	**1.34**	**1.61**
Average 1987-2003	**Na**	**0.18**	**0.97**

V. CONCLUSIONS

This report has discussed PG&E's and ORA estimates of electric and gas distribution TFP growth rates from 1987 through test year 2003. PG&E's estimates of TFP growth are based on two output measures-total sales and total customers.

For the electric department PG&E concludes that when output is measured as total sales, electric distribution department TFP averaged –0.28 percent per year over the 1987-2003 period. If customers are the output measure electric TFP growth averages –0.01 percent over the 1987-2003 period. ORA arrives at similar conclusions. With output measured as the revenue weighted share of sales to the residential, commercial, large light and power, agricultural, and other public authority classes of service, ORA concludes that electric TFP growth averaged 0.25 percent per year over the 1987-2003. Finally, ORA notes that both PG&E and ORA's results are consistent with the most recent study of nationwide electric distribution TFP growth. This nationwide study concluded that over the 1990-2001 period nationwide electric distribution TFP growth averaged 0.50 percent per anum.

PG&E's approach to measuring gas distribution TFP growth is similar to its electric department approach. When output is measured as total gas sales, gas department TFP growth averages 0.39 percent over the 1987-2003 period. If customers are the output measure gas TFP averages 1.35 percent per year. ORA arrives at lower gas department TFP growth rates. ORA concludes that over the 1990-2003 period gas department TFP averaged 0.22 percent over the 1990-2003 period. Over the historic, 1990-2001 period, ORA results show a decline in gas TFP growth of 0.35 percent per year. A recent study of nationwide gas distribution productivity growth concluded that the trend growth in TFP for this industry averaged 0.93 percent per year for the same period.

APPENDIX

This appendix discusses the methodology used by PG&E and ORA to construct aggregate input and output indexes as well as the construction of the specific inputs and outputs used in this report.

DIVISIA INDEX

A common procedure to aggregate inputs is to rely on the Tornqvist approximation to the Divisia index. The Tornqvist approximation to the Divisia index is shown in equation (1).

(1) $\log (Qi,t/Qi,t-1) = .5* (Si,t + Si,t-1)* \log (Xi,t/Xi,t-1)$

In this case Qi,t is the aggregate input index in period t, and Qi,t-1 is the aggregate input index in period t-1. Si,t is the cost share of input Xi in period t, and Si,t-1 is the cost share of input Xi in period t-1. As an example consider a firm producing a single output with two inputs labor (Xl) and capital (Xk). In this case, aggregate input between two periods t and t-1 would be:

(2) $g\ QI = .5*(SL(t) + SL(t-1))*g\ XL + .5*(SK(t)+SK(t-1))*g\ XK$

Where:

g QI = Total input growth

SL(t) = Labor cost share in period t

SL(t-1) = Labor cost share in period t-1

gXL = Labor input growth, log (XL(t)/XL(-1))

SK(t) = Capital cost share in period t

SK(t-1) = Capital cost share in period t-1

gXK = Capital input growth, log (XK(t)/XK(t-1))

The Tornqvist approximation index weights each input by its relative cost share. This gives greater weights to inputs with relatively larger cost shares.

OUTPUT

In its report on Total Factor Productivity PG&E used three measures of electric output defined as total electric sales, total electric sales plus conservation, and total electric customers. Similar measures were used to measure gas department output. In response to ORA Data Request C-TMR-126, PG&E explained that "The estimates of conservation impacts for the electric and gas departments came from PG&E's Customer Energy Management (CEM) organization. These estimates represent a running total of energy conservation projections and tie to annual conservation estimates in the Energy Efficiency Programs Annual Report and the Low Income Energy Efficiency Annual Report, both filed on May 1, with the CPUC each year." (Pacific Gas and Electric, Test Year 2003, Response to ORA Data Request No. C-TMR-126, December 6, 2002).

For the electric department ORA constructed a Divisia index of output based on revenues and sales to the residential, commercial, large light and power, agriculture and other public authority classes of service. The commercial class includes the small light and power and medium light and power classes of service. This data was provided by PG&E in response to ORA Data Request C-TMR-126-06, November 27, 2002.

For the gas department ORA constructed a Divisia index of output based on revenues and sales to the residential, commercial, industrial, cogeneration, utility electric generation, and wholesale classes of service. The data was only available from 1990 forward. This data was provided by PG&E in response to ORA Data Request C-TMR-126-06, November 27, 2002.

LABOR

PG&E constructs estimates of labor quantities for the electric and gas departments by dividing the cost of labor by a suitable price index. The cost of labor for the electric and gas departments is equal to the sum of distribution wages and salaries, pensions and benefits, and payroll taxes. The price of labor for the electric and gas departments is defined as California Wages and Salaries plus California Other Labor Income divided by California Non-Agricultural Employment. The source for this data is DRI/WEFA RIS/Forecast 0102. In its analysis of PG&E's electric and gas department TFP growth rates ORA relied on PG&E's representation of the cost and quantity of labor.

CAPITAL

To derive estimates of the capital stock for its electric and gas departments PG&E relies upon the geometric decay method. The geometric decay approach is shown in equation (3)

(3) $K(t) = (1-d)*K(t-1) + I(t)$

In equation (3) K(t) represents the constant dollar capital stock in period t, d, the depreciation rate, K(t-1), the constant dollar capital stock in period (t-1), and I(t) constant dollar gross investment in period t. Virtually all studies of TFP growth rely upon the geometric decay method.

For the electric department the capital stock consists of distribution plant plus a portion of common and general plant allocated to distribution. The gross investment series is derived by deflating historic nominal distribution and common/general plant additions by the appropriate Handy-Whitman indexes. The depreciation rate, d, is based on the useful life of distribution plant and common/general plant. For distribution plant PG&E assumes a useful plant life of 40 years while for common/general plant the assumed useful life is 21 years.

For the gas department the capital stock is comprised of distribution plant plus a portion of common and general plant allocated to gas distribution plant. As in the case of the electric department, the gross investment series is derived by deflating historic nominal additions by the appropriate Handy-Whitman indexes. The gas depreciation rates, d, are based on the useful lives of the respective plant types. For gas distribution the assumed useful plant life is 39 years and, as in the case of the electric department the assumed useful life of common/general plant is 21 years.

For the electric and gas departments the price of capital is measured as:

(4) $Pki(t) = HWi(t)*(di(t)+ROR)$

Where:

Pki(t) = Price of capital in period t for asset type (i), i.e. distribution plant

HWi(t) = Handy-Whitman index in period t for asset type (i), i.e. distribution plant.

ROR = Authorized rate of return.

This is often referred to as the user cost of capital.

The Tornqvist approximation to the Divisia index is then used to arrive at aggregate measures of the capital stock for the electric and gas departments.

MATERIALS

The cost of materials is defined as non-labor, non-fuel operations and maintenance expenses. For the electric department, the quantity of materials is derived by dividing the cost of materials by a price index reflecting price escalation for electric and gas materials. This index, JEDOMMS, is taken from DRI/WEFA Utility Cost Forecasting Service. A similar approach is used for the gas department. For the gas department gas non-labor, non-fuel operations expenses are deflated by the index JGDOMMS. This index is also taken from the DRI/WEFA Utility Cost Forecasting Service.